Comments on the RDOF Uplink Service Objective

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Background: 100/10 Mbps vs. 100/20 Mbps

- The 20 Mbps uplink objective likely adds substantial cost without corresponding consumer benefit.
  - Traffic is typically 90% download/10% upload – thus unlike 100/20, the 10/1, 25/3, 50/5 Mbps service tiers are better matches with actual traffic usage.

- In considering fixed wireless deployment scenarios, a 20 Mbps uplink tier likely adds two to three times the cost compared to a 10 Mbps uplink deployment, due to the need to build additional sites.
  - These increased costs translate to:
    - Reduced competition at the 100 Mbps tier;
    - Reduced broadband deployed in the RDOF.

- While 100/20 Mbps was used in the CAF-II Auction, in many consumer applications, 10 vs. 20 Mbps upload is unlikely to drive differences in the actual usage or service offerings – e.g. HD streaming, video calls, online gaming.

RDOF Uplink Service Objective and CBRS

- The RDOF Uplink objective is biased towards operators who do not have to rely solely on CBRS and/or which have considerable other spectrum resources they can use (with or without carrier aggregation with CBRS).
  - Intra-band Carrier Aggregation (PAL − Band 48) − channel bandwidths are 10 MHz or 20 MHz; can combine up to five 20 MHz channels to get up to 100 MHz…
  - But any one operator can only acquire 4 PALs under the FCC's draft rules, so have to rely on combining PALs with GAA.

- For operators with limited spectrum resources, and that may be considering deployment using CBRS only − Band 48, the upstream target will be difficult if not impossible to meet in many cases with 20 MHz of spectrum, and even potentially in cases where a carrier could acquire the full 40 MHz allowed.

- And specific to CBRS, there is limited equipment available − a number of the certified OnGo CPE devices only support Band 48. And there are limited carrier aggregation opportunities available.

Current CBRS CPE and Spectrum

- The table below summarizes bands supported by a selection of CBRS OnGo Certified CPE devices:

Examples of OnGo Consumer CPE Devices		600 MHz 71	700 Lower 12	700 Upper 13	Cellular 5, 26	AWS 1 4	AWS 1/3 66	AWS 3/4 70	PCS 2	PCS G 25	BRS/EBS 41	LAA 46	CBRS 48
Fixed	Zyxel LTE Outdoor router Telrad CPE 9000 GreenPacket OT235 BEC 6900 Outdoor router (1)												
Mobile	Inseego 5G MiFi Hotspot (2) Apple iPhone 11 Motorola 5G Moto Mod (2)												

(1) BEC 6900 CBRS version - only supports Band 48, but provides for intra-band 3x CA downlink and 2x CA uplink (Model 6900 R21); Telrad provides 2x CA

(2) In addition to bands shown device also supports 5G mmWave 37/39 GHz (band n260) and 28 GHz (band n261)

- In total there are 54 approved OnGo end user devices. Over 50% (28 devices) are mobile phones or hotspots, 24% (13 devices) are "modules". Only four OnGo devices are specifically targeted for fixed wireless deployment as would be relevant to RDOF.
- The four consumer CPE devices for Fixed Service applications only support Band 48.
  - Thus, they work with limited spectrum resources – max 40 MHz PALs, combined with GAA,
  - By only supporting one band, there are no inter-band carrier aggregation options available that could be used to increase overall throughput.
- On the other hand, the sample of three devices designed for mobile support a broad set of bands, which provide for more options to meet different service objectives.
- Fixed service operators do not necessarily have access to multiple bands, and in any case do not have the mobile infrastructure to support these devices.

CBRS Configurations

- Also an important consideration is that TD-LTE for Band 48 operates with fixed configurations sharing bandwidth between UL & DL:
  - Frame Config 1 has ~55% devoted to DL and 40% devoted to UL
  - Frame Config 2 has ~75% devoted to DL and 20% devoted to UL
- Configuration 1 provides greater capacity for uplink, but may have insufficient capacity to meet the 100 MHz downlink objective.
- Given the importance of downlink speed, however, Configuration 2 is typically used by vendors as it most closely matches Internet traffic profiles. In this case there is less spectrum available for uplink.
  - And operators using TDD in common band in the same area need to coordinate configuration to minimize interference (and maximize spectrum allocation).
- The design of the customer premises equipment (CPE) is what dictates uplink performance. The following analysis provides a basic performance comparison of two CBRS CPE devices – **NOTE**: the analysis is "best case" under ideal conditions, not accounting for specifics of terrain or geography.

CPE and Uplink Performance

- Considering two examples of CPE…

- CPE Device #1 – Zyxel – It is designed for fixed service and supports 573 Mbps downlink but only **15 Mbps uplink. This does not meet CAF-RDOF 20 Mbps uplink requirement (for Above Baseline service).** The device uses Band 48 only.
  - Downlink 256 QAM with 4x4 MIMO; Uplink is 64 QAM and no MIMO
  - The device uses TDD Configuration 2 – UL:DL ratio 2:6 – so DL is 75% of the 20 MHz channel.

- CPE Device #2 – Inseego – It is designed for mobile service and supports 2 Gbps downlink and uplink speeds up to 316 Mbps. The device supports Bands 2 (PCS), 4 (AWS), 5 (Cellular), 13 (Lower 700), 48 (CBRS), 66 (AWS), with up to 5 x carrier aggregation (i.e. 5x20 MHz). It also supports mmWave bands n260 and n261 – 39 GHz and 28 GHz.
  - On downlink it uses 4x4 MIMO, 256 QAM and 5x carrier aggregation (LTE UE Category 20), For uplink it uses 256 QAM and provides for 3x carrier aggregation (LTE UE Category 13).

Performance Comparison

- With CPE Device #1 performance, the RDOF Above Baseline service objective often cannot be met – downlink and uplink (since uplink is limited to 15 Mbps maximum).
- Even with the more advanced CPE Device #2 performance, with only 20 MHz of spectrum, the objectives are often not met. With 40 MHz of spectrum, the Device #2 scenario meets objectives more often using 50% downlink, 50% uplink.

Spectrum MHz	Range of Subscriber Density					
	Subscribers per site	10	15	20	25	30
20 MHz	CPE Device #1 performance (Zyxel)					
	Down Mbps	113	75	56	45	38
	Up Mbps	15	13	9	8	6
	CPE Device #2 performance (Inseego)					
	Down Mbps	100	67	50	40	33
	Up Mbps	50	33	25	20	17
40 MHz	CPE Device #1 performance (Zyxel)					
	Down Mbps	225	150	113	90	75
	Up Mbps	15	15	15	15	13
	CPE Device #2 performance (Inseego)					
	Down Mbps	200	133	100	80	67
	Up Mbps	100	67	50	40	33

Device #1 uses 75% of MHz for downlink (Configuration 2) but is limited to 15 Mbps uplink
Device #2 uses 50% of MHz for downlink (Configuration 1)

- One way of improving performance is to increase the number of sites, which in turn increases deployment costs. As shown above, with more sites and thus lower subscriber counts per site, the performance objectives are met in more cases, but not always.
- To achieve this, however, the number of sites would have to be doubled or tripled – i.e. by increasing deployment to reduce subscribers from 20-30 per site down to 10 per site.

Conclusions

- For an operator to deploy CBRS, there is limited equipment available – a number of the certified OnGo devices only support Band 48.
  - There are also limited carrier aggregation opportunities available for Band 48
- The FCC objectives for 100/20 do not respect the relative downlink vs. uplink performance in particular of CBRS equipment. On the other hand, using 75% of MHz to support downlink (CBRS TDD Configuration 2) would better meet 100 Mbps objective, and would more readily provide at least 10 Mbps uplink instead of 20 Mbps.
- One way of improving performance is to increase the number of sites, which in turn increases deployment costs. To achieve this, however, the number of sites would have to be doubled or tripled – making deployment much less economic.
- The RDOF Uplink objective is biased towards operators who do not have to rely solely on CBRS and/or which have other spectrum resources they can apply (meeting objectives with carrier aggregation).
- ***If the Uplink objective were changed to 10 Mbps, this would allow operators to meet the Above Baseline service objective on a much broader basis. This would increase competition for the Above Baseline service objective and increase deployment in currently underserved and unserved areas.***

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